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Stainless-Steel Soil Solution Sampler for Monitoring Pesticides in the Vadose Zone

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A STAINLESS-STEEL SOIL SOLUTION SAMPLER FOR MONITORING PESTICIDES IN THE VADOSE ZONE[1]

C. N. SMITH AND R. F. CARSEL[2]

Abstract

A design for an in situ soil solution sampler (suction lysimeter), consisting of a stainless steel tube with a 0.1 MPa (−1.0 bar), high-flow, porous ceramic cup, is presented for use in monitoring pesticide or other dissolved chemical leaching in the vadose (unsaturated) zone. The sampler is of one piece construction with the porous ceramic cup attached by epoxy adhesive. The design permits collection of a total volume of up to 0.5 L of soil solution per sample. Laboratory studies indicated that pesticide sorption on the sampler was insignificant and no analytical interference problems were observed. The samplers were designed to monitor leaching of pesticides and inorganic tracers in an on-going field study in southwest Georgia. Successful field performance of 60 installed samplers (depths of 1.5, 2.1, and 2.7 m) was demonstrated during the 1984 cropping year. Soil solution sample volumes of 10 to 500 mL were obtained during one 24-h sampling period with vacuums of 0.015 and 0.020 MPa.

Additional Index Words: **leaching, lysimeter, drainage water.**

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RECENT INCIDENTS of pesticide contamination of groundwater have led to increased emphasis on evaluating the leaching potential of these compounds. To this end, the U. S. Environmental Protection Agency and the U. S. Geological Survey are conducting a field study in southwest Georgia to develop data for predicting pesticide leaching threats to groundwater. Part of this research involved developing a method for monitoring pesticide movement.

Monitoring chemical leaching through the vadose (unsaturated) zone requires disruptive sampling of soil cores or nondisruptive, in situ sampling of soil solution. Various types of tension or suction lysimeters have been used for sampling nutrient concentrations in soil water. These can be constructed of porous ceramic discs, plates, or cups of several sizes, or of porous Teflon cylinders (Haines et al., 1982). A review of the different methods for monitoring chemical movement in the unsaturated zone has been presented by Wilson (1980) and Morrison (1983).

This note presents the design, construction, installation procedure, and the results of a field performance test for a stainless-steel soil solution sampler for use in monitoring the leaching of pesticides (or other, organic and inorganic chemicals) in the unsaturated soil zone of an agricultural field or waste disposal site. The stainless-steel sampler was constructed after samplers made of either polyvinyl chloride (PVC) plastic or Teflon® proved to be unacceptable for use in the study[3].

Materials and Methods

Sampler Design, Materials, and Testing

The sampler (Fig. 1) was constructed from 3.81-cm (diam), schedule 10, welded-type, 316 stainless-steel pipe (4.76-cm o.d.). One end of the pipe was enclosed using a plate of 11-guage stainless steel. A stainless-steel vacuum tube (part 1) was positioned to extend through the end plate. A stainless-steel sample tube (part 2) was positioned to extend through the length of the sampler and into a ceramic porous cup. A stabilizer fabricated from three 16-guage, stainless steel, moon-shaped cut-outs was secured to the sample tube (Fig. 1). An installation hanger was secured to the top of the sampler (part 3; Fig. 1) for use in lowering the device into bore holes. The required finished inside pipe diameter for custom-fitting the ceramic cup was determined by measuring the diameters of 10, randomly selected, standard, high flow ceramic cups (available from Soil Moisture Equipment Co., Santa Barbara, CA). The smallest diameter that produced a tight fit was selected. Prior to installation of a ceramic cup, each sampler was thoroughly cleaned with water and alconox detergent, placed in 1 *M* HNO_3, rinsed with distilled water, and rinsed with acetone.

Once the cup was fitted to the opening, a two-part epoxy resin (available from Soil Moisture Equipment Co., Santa Barbara, CA) was applied to the inside of sampler and around the neck of the ceramic cup. The cup was inserted into the sampler and rotated to spread the epoxy. The epoxy was allowed to cure for 2 to 3 d with the sampler supported in a vertical position.

After the adhesive had cured, all samplers were placed in a container of distilled water to allow saturation of the ce-

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[3] Mention of trade names or commercial products is for informational purposes only and does not constitute endorsement or recommendation for use by the U. S. Environmental Protection Agency.

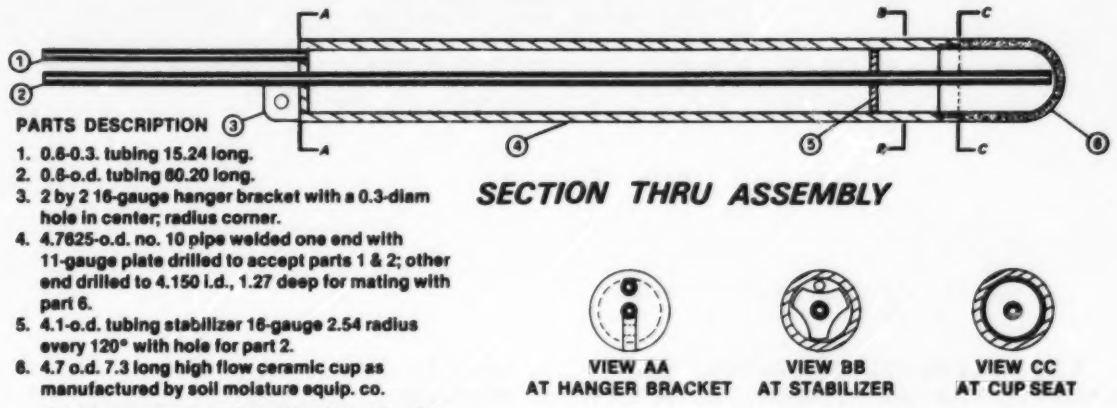
PARTS DESCRIPTION
1. 0.6-0.3. tubing 15.24 long.
2. 0.6-o.d. tubing 60.20 long.
3. 2 by 2 16-gauge hanger bracket with a 0.3-diam hole in center; radius corner.
4. 4.7625-o.d. no. 10 pipe welded one end with 11-gauge plate drilled to accept parts 1 & 2; other end drilled to 4.150 i.d., 1.27 deep for mating with part 6.
5. 4.1-o.d. tubing stabilizer 16-gauge 2.54 radius every 120° with hole for part 2.
6. 4.7 o.d. 7.3 long high flow ceramic cup as manufactured by soil moisture equip. co.
(All measurements are in centimeters; all metal parts are type 316 stainless steel.)
SECTION THRU ASSEMBLY
VIEW AA AT HANGER BRACKET
VIEW BB AT STABILIZER
VIEW CC AT CUP SEAT

Fig. 1. Illustrative sketch of sampler.

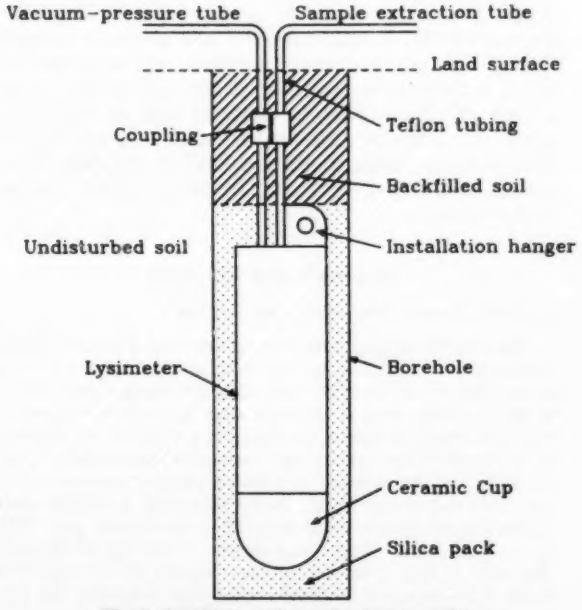

Fig. 2. Installation of sampler (not to scale).

ramic cup. Each sampler was then tested for leaks under a vacuum of 0.07 MPa (70 centibars). The total volume of the sampler was 0.5 L. Additional testing was conducted to determine sorption losses of the pesticide aldicarb on the sampler. Studies were conducted by pulling known concentrations of aldicarb solution through the ceramic cup into the sampler. Samples were analyzed by high performance liquid chromatography at 0 and 4-d time intervals. Pesticide sorption and analytical interference problems were not observed.

Installation

Teflon tubing (0.38-cm i.d., 0.64-cm o.d.) was cut to desired lengths and connected to the sample and vacuum tubes of the sampler using a stainless steel (316 Type) Swagelok fitting (union-fractional tube to fractional tube) with a monel rear ferrule. The stainless-steel fitting with monel rear ferrule was used to minimize corrosion. Each sampler was retested for vacuum leaks after installation of the sampling lines, and each sample and vacuum line was labeled using gas chromatograph column tags. Gas chromatograph column end caps (0.6-cm diam) were inserted into the end of each Teflon tube for protection from soil and dust particles.

Sixty boreholes were hand drilled into the soil at 20 predetermined field sampling sites to depths of 1.5, 2.1, and 2.7 m (spaced 0.3-m apart) using a 5.7-cm diam hand auger. A 5-cm o.d. PVC pipe (cut to maximum depth for locating sampler) was inserted into each borehole and used as a liner to center the installed sampler. A silica flour slurry (150 mL) was poured into each borehole to provide a seal between the soil and the ceramic cup of the sampler. The samplers were lowered into each developed borehole (see Fig. 2). The PVC pipe was raised to the top of the sampler, and an additional 0.95 L of silica slurry was poured into each borehole to provide a seal between the sampler and the surrounding soil. The silica slurry was allowed to dry for 24 h, and each borehole was backfilled with soil (which had previously been removed from the bore hole) packed by gentle tamping to provide a seal above the installed samplers.

To allow normal field management practices (moldboard plowing, planting, and pesticide application), sample and vacuum tubing from the three samplers at each monitoring site was coiled inside an automobile brake drum (with a 0.15-m diam hole cut in the center) and buried to a depth of 0.45 m. A metal detector was then used to locate the brake drum after planting and pesticide application was completed.

A 0.10-m diam hand auger was used to bore a hole to the top of the brake drum for recovery of the sampler tubing. The 0.15-m opening in the brake drum and the use of a 0.1-m hand auger allowed minimum soil disturbance when sampler tubes were recovered.

Sampler Operation

Prior to collecting a sample, vacuum was applied (using a hand pump) to remove any capillary water stored in the sampler. The amount of vacuum applied was determined from soil tensiometers installed at each monitoring site (e.g., the amount of vacuum should not exceed the tension at which water was held in the soil). During sampling, the vacuum was released, a collection bottle was connected to sample tube (no. 2), and the vacuum was reapplied to collect the solution sample.

Field Performance

The sampler has been used successfully in a field study on the migration of pesticides in the unsaturated soil zone in southwest Georgia (U. S. Environmental

Protection Agency, Internal Report). During the spring of 1984, the field was moldboard-plowed and planted to peanuts (*Arachis hypogaea*) and pesticide was applied. Soil water samples were taken after each of four rainfall events that occurred during the 1984 cropping year. All samplers (60 samplers, three per monitoring site) performed well and little effort was required in using a hand pump to collect samples. Sample volumes of 10 to 500 mL were obtained during 24-h sampling intervals with vacuums of 0.015 and 0.020 MPa.

It is expected that the stainless-steel soil solution sampler can be used with minimum sorption for most pesticides. Although the 316 type stainless steel minimizes sorption, one must conduct actual sorption studies on each compound of interest because the ceramic cup has been shown to reduce concentrations of some pesticides and metals (Morrison, 1983). Because of the one piece construction with a high flow porous cermic cup rated at 0.1 MPa, potential vacuum leakage problems were minimized. The weight of the sampler was found to be an advantage in that it provided sustained contact with surrounding soil.

The cost of constructing the sampler with the commercially available porous ceramic cup is approximately $50.00.

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